CIDER VINEGARS

OF

PENNSYLVANIA.

BY

DR. WILLIAM FREAR,

Chemist to the Pennsylvania Department of Agriculture.

PUBLISHED BY DIRECTION OF THE SECRETARY.

CLARENCE M. BUSCH,
STATE PRINTER OF PENNSYLVANIA.
1897.

LETTER OF TRANSMITTAL.

Pennsylvania State College
Agricultural Experiment Station,
February 15, 1897.

Hon. Thos. J. Edge, Secretary of Agriculture, Harrisburg, Pa.:

Sir: I have the honor to transmit herewith a report upon the results of the investigation into the strength of the cider vinegars made by reliable domestic makers in the several parts of the State and collected for examination, according to your directions, to ascertain whether they meet the requirements fixed by the existing legal standard.

Very respectfully,
WILLIAM FREAR,
Chemist.

INTRODUCTION.

Department of Agriculture,
Harrisburg, Pa., February 16, 1897.

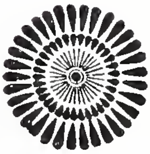
Quite early in our work of carrying into effect the acts of June 11, 1891, and July 5, 1895, relating to the manufacture and sale of cider vinegar, it was found that some samples which were apparently pure ran below the standard in solids; in view of this fact the Department, in enforcing the law, accepted a standard below the legal requirement, and assumed that two per cent. was too high a standard for the minimum sample.

It was and is admitted that cider vinegar may, and very often does run above two per cent. in solids, but it was deemed unjust to hold the manufacturers up to the higher standard when it was apparent that vinegar, made under unfavorable circumstances and surroundings possibly, but pure and unadulterated, did not contain the two per cent. required by existing laws.

No little difficulty was found in the enforcement of these laws from the fact that they applied to cider vinegar alone, and that other classes of vinegar might run very much lower in acidity and be adulterated to an almost indefinite extent.

In view of these facts, and others which might be stated, the Department has asked the Legislature to place all kinds of vinegars under a proper supervision of the law, and establish a minimum standard for all, thus removing the inequalities which now exist, and enabling the Department to exact strict justice from all.

THOS. J. EDGE,
Secretary.



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BY DR. WILLIAM FREAR, *Chemist to Pennsylvania Department of Agriculture*

Vinegar is essentially a dilute solution of acetic acid containing also salts, flavoring and coloring matters, as well as indifferent solids. These additional substances vary in kind and amount with the material from which the vinegar is made, and are often of considerable importance as imparting to vinegar from a given source, its most highly prized, distinctive quality.

Table vinegars are usually prepared by the acetification of alcoholic liquids, such as cider, wine, malt liquors, or "low wines" (distilled grain spirits of little concentration); sometimes, however, they are simply dilute solutions of the acetic acid obtained by heating non-resinous woods in close retorts, the usual coloring of the fruit vinegars being easily imitated.

The use of the several vinegars varies much in the different civilized countries; so that, on the continent of Europe, the term "vinegar," if used without a distinctive qualifying word, means wine-vinegar; in England, malt-vinegar: in Canada, spirit-vinegar, and in the United States, cider-vinegar. So far as their use as preservatives, and as agents for dissolving and softening certain food constituents is concerned, there is probably little difference between these vinegars, providing that they are of normal strength and contain equal percentages of acetic acid. Vinegars are, however, chiefly used as condiments, i. e., to give flavor and pungency to food. In this relation, the fruit vinegars are far more highly valued because of the delicate flavors imparted by the fruit-ethers they contain, when properly made and stored.

Since the alcohol derived from grain, either in malt liquors or "low wines," or from sugar-refinery wastes, is much cheaper than that obtained from fermented fruit juices, the market has been largely stocked with cheap imitations of the fruit vinegar. To protect the unwary buyer from deception, either through the substitution of cheap imitations for the genuine fruit vinegar, or through the fraudulent dilution of a vinegar of any kind, many foreign countries, and many states and municipalities of this country have enacted laws fixing the standards for one or more of the several classes of vinegars above-mentioned, and prescribing penalties for the sale of vinegars that fall below such standards or are plainly adulterated by the addition of injurious substances.

VINEGAR STANDARDS.

By the act of June 11, 1891,* the Legislature of Pennsylvania fixed as a standard for cider vinegar, that it shall contain not less than four per cent. of acid, and not less than two per cent. of cider-vinegar solids, left after full evaporation over boiling water. This act also prohibited the addition of coloring matter to cider vinegar, required the branding of all packages of vinegar offered for sale, forbade the use of the brand "cider vinegar" or "fruit vinegar" unless the vinegar be made wholly from apples or from other fruits, and prohibited the sale of vinegar containing any ingredient injurious to health.

Among the standards for cider vinegar fixed by other states, territories and municipalities, the following may be mentioned:†

	Acetic Acid, per cent.	Solids, per cent.
Boston, Mass., ...	5	1.5
District of Columbia, ...	5	1.5
Minnesota, ...	4.5	2.0
Ohio, ...	4	2.0
Wisconsin, ...	4	2.0

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* Pamphlet Laws of 1891, p. 297.

† NOTE BY THE SECRETARY.—The standards established for vinegar by other states are as follows:

Connecticut—Four per cent. of acidity, and, if cider vinegar, two per cent. of cider vinegar solids. *Indiana*—Four per cent. of acidity, and, if cider vinegar, two per cent. of solids; coloring matter is prohibited. *Massachusetts*—Four per cent. of acidity, two per cent. of solids and coloring matter prohibited. *Michigan*—Four per cent. of acidity, one and three-quarter per cent. of solids, and coloring matter prohibited. *Minnesota*—Four and one-half per cent. of acidity, one and three-quarter per cent. of solids and no coloring matter permitted. *New York*—Four and one-half per cent. of acidity, two per cent. of solids, and coloring matter prohibited. *Ohio*—Cider vinegar must contain four per cent. of acidity and two per cent. of solids, and no coloring matter allowed. *Pennsylvania*—Four per cent. of acidity, two per cent. of solids, no coloring matter to be used in cider vinegar, and all barrels must be branded according to the provisions of law. *Wisconsin*—Four per cent. of acidity, two per cent. of solids, and all barrels must be branded as provided by law.

These figures differ considerably from those found in other vinegars, especially the figures for solids. Wine vinegar often contains no more than 0.4 per cent.; spirit vinegars rarely contain as much as 0.3 per cent.; malt vinegars, on the other hand, usually contain 3 to 6 per cent. of solids.

In view of the fact that the Pennsylvania enactment, above mentioned, not only fixed the standard of strength for cider vinegar, but also imposed penalties of fine, imprisonment and forfeiture for a violation of its provisions, many questions have arisen not only on the part of the consumers and of the grocers, who are first to suffer the penalty of such violation, but also on the part of the farmers, who are anxious that they shall not unwittingly fall under the ban of the law by offering for sale cider vinegar that is not standard. Prominent among these questions are the following:

(1) Is it possible for a careful vinegar maker, adopting the methods usually followed on the farm and using nothing but the pure apple juice for the purpose, to fail to attain the minimum limit for solids and thus subject himself and the grocer who buys his product to legal penalties?

(2) It is a matter of common belief that the cider of New England, New York and other more northerly states is superior to that of Pennsylvania and more southerly states. Is it possible that the standard acceptable in more northerly climates is for that reason, not suitable for Pennsylvania?

(3) Will the vinegar tester now so largely offered for sale to grocers and farmers, which is simply a densimeter or hydrometer, give trustworthy indications of the standard nature of a vinegar?

To answer some of these questions required more information than was at hand concerning Pennsylvania cider vinegars of known origin. A simple investigation of the cider vinegars of domestic manufacture in various counties of the State was, therefore, begun. Before presenting any statement of its method and results, a brief outline of the more important elements of cider vinegar making may be useful.

Cider Vinegar Making.

Fruit sugars are the real source of the acetic acid of fruit vinegars. The sugary juices are first fermented, the sugars being thereby converted into alcohol; the alcohol is then changed by action of the acetic ferment into acetic acid. The process is really much more complex than would appear from this simple statement, owing to many secondary changes that occur at the same time.

The sugar is, theoretically, capable of yielding for each 100 parts, expressed as grape sugar, 51 parts of alcohol; as a matter of fact, however, it requires 105 parts of the sugar to produce this much alcohol, since four parts are turned into succinic acid, glycerol, etc., and one part is absorbed permanently by the yeast producing the alcoholic fermentation. Further, there is always some loss of the alcohol under ordinary conditions of storing the cider. The actual production is fairly shown by the following analyses by Kayser,* giving the composition of the fresh apple juice and of the cider made from it.

		Apple Juice, per cent.		Cider, per cent.	
Water,	Volatile,	83.75	83.75	92.92	97.64
Alcohol,		....		4.64	
Acetic acid,		....		.08	
Fruit ethers,		....		....	
Sugar,	Solids,	12.50	16.25	.75	2.36
Glycerol,		....		.68	
Malic acid,		.33		.30	
Gums, jelly-forming substance, etc.,		3.07		.32	
Ash,		.35		.31	
		100.00		100.00	

The cider obtained had the following constituents: Alcohol, sugar, gums, jelly-forming substances, glycerol, malic, tartaric, butyric, acetic, oxalic, succinic and lactic acids, tannin, salts and certain ethers imparting what is known as the "bouquet" or distinctive flavor.

This complex liquid is then put through a process of oxidation, which is largely brought about by the aid of a special organism, the acetic ferment. This ferment, which, in a certain state of its development, gathers in films forming what is known as the "mother of vinegar," requires for its highest activity free access of air, a favorable temperature (76 degrees to 82 degrees Fahrenheit) and a liberal supply of food—alcohol, certain organic matters and salts. In case the food supply fails and the other conditions of activity remain favorable, much of the acetic acid formed is, in turn, destroyed by further fermentative action.

In the ordinary domestic manufacture of vinegar, the cider having been started into a vigorous alcoholic fermentation, often promoted by exposing the barrels containing it to the sun, it is transferred to a barrel formerly used for vinegar making—if that into which it was originally poured was not a vinegar barrel; the barrel is only partly filled; some "mother" from old vinegar is often added; the cider is then stored in the cellar, or some other room of moderate temperature, and allowed to stand for several years to permit the completion of the slow oxidation process.

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*Repertorium f. analyt. Chemie, 1882, p. 534.

In what is known as the "Orleans process," the barrel is partly filled with a mixture of old vinegar and cider; as soon as the acetification of the cider is complete—the speed of oxidation being increased by the presence of the old vinegar—one-half of the mixture is drawn off, and a fresh portion of cider is again added, and the process renewed.

The "Dutch process" is a much quicker one. Vats filled with thick shavings, whose surfaces are overgrown with the vinegar ferment, receive trickling streams of warm cider from a tank above. These are met by a rapid current of air arising through ventilators about the bottom of the vat. The liquid dripping from the shavings is completely acetified. This process is employed in most large vinegar-making establishments. Whenever a high temperature or a rapid current of air is used to hasten the process, it is always at the expense of part of the alcohol, which is volatilized. The loss is often very considerable, sometimes fully one-third. Some loss attends every process; so that, although the theoretical yield is nearly five parts of acid for four parts of alcohol, or eight parts of sugar, the actual results obtained in practice fall much below these figures.

Influence of Climate Upon Apples.

The apple is greatly influenced in its sweetness and flavor, not only by the variety from which it springs, but also by local conditions of moisture, temperature, sunshine, etc. A fruit of the temperate zone, it does not reach its highest perfection either in the more northerly districts of European Russia, nor in Italy, Southern France, or the Southern United States. So responsive, however, is the fruit to variations in soil temperature and texture, exposure to sunshine, etc., that it is very doubtful whether the average fruits from different geographical districts within the temperate zones—after making proper allowance for time of maturing—differ in quality as much as those grown at different altitudes and upon different soils and exposures of the same region. The following brief table gives a comparative view of the composition of apples from different parts of the North Temperate zone:

COMPOSITION IN PERCENTAGES OF THE WHOLE FRUIT.

Locality.	No. of sorts.	Water.			Sugar.			Analyst.
		Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	
Germany.	3	85.04	82.13	83 22	8.98	7.58	8.06	R. Fresenius, 1.
Wurtemburg, Germany, . .	8	. . . .	. . . .	84.74	. . . .	. . . .	7.46	Wolff, 2.
Germany, ...	5	87.31	81.47	84.77	7.80	5.95	7.53	Pfeiffer. 3.
Bohemia, ...	3	84.11	81.29	82.85	8.76	5.49	7.18	Margold, 4.
Livonia, Russia, ...	16	89.00	82 76	86.09	8.43	5.00	6.60	Dragendorff, 5.
United States, ...	18	89.40	84.60	86.43	12.77	8.50	10.26	Richards, 6.

1. Ann. Chem. Pharm. **101,** p. 219.
2. Wurttemb. Wochenbl. Land. u. Forster, 1856, No. 18.
3. Jahresber. Agric. Chem. 1875-76, p. 313.
4. Ib., 1861-62, p. 51.
5. Ib., 1878. p. 114.
6. Report. U. S. Dept. of Agric., 1886, p. 354.

While the apples of the United States and Livonia contain the least solids, those of the former county are the sweetest of all these analyses that are here given, those of the latter the least sweet.

While certain low-lying orchards of Pennsylvania upon wet clay soils, and not fully exposed to the longer periods of sunshine, may produce fruit of deficient quality, this is not attributable to general climate. Some of the lower tier of counties in this State produce fruit of as high color, rich flavor and great sweetness as that produced in New York, New England or the northwestern states.

CIDER VINEGARS OF PENNSYLVANIA.

During the fall of 1896, circulars were sent to selected correspondents of the Experiment Station, in the several counties of the State, requesting their co-operation in securing from their respective counties representative samples of pure cider vinegar made by most trustworthy farmers, and blank forms were supplied in order that the fullest information upon all important points in the history of each sample might be elicited. No statement was made in these circulars of the object of the investigation.

Only sixty-four samples were received, representing thirty-one counties, of which two thirds, were situated east of the Alleghenies. Replies from correspondents in a number of the remaining counties stated that, owing to the competition of cheaper vinegars, the domestic manufacture of cider vinegar for sale has been greatly reduced. In a good many instances the correspondents stated that it was impossible to secure samples of genuine, pure, undiluted cider vinegar of known age. Most frequently, this was due to the prevailing practice of adding new cider yearly to the barrels containing the older vinegar; if this process is carried on systematically so that the stronger vinegar only is offered for sale, there are excellent reasons for its adoption. There is evidence, however, that sufficient care is not always exercised upon this point; so that low grade vinegar is placed upon the market as a result of over-haste in the making. It is possible, on the other hand, that too rapid and prolonged action of the ferments upon the old vinegar may seriously decrease its strength in both acid and solids—though the evidence of loss of solids is not so clear as is that of loss of the acid.

It is also stated in many cases that water is added. The first pressing of the apples fails to remove at all completely the sugars they contain; especially is this true where hand presses are employed. To recover as much as possible of these valuable constituents, the pomace is often watered and again pressed. Ordinarily, the mixture of the juices from the two pressings is weaker than the normal cider; and this diminishes the strength of the vinegar.

In other instances, water is added to sluggish ciders in order to hasten the acetification. Finally, very strong vinegar is often diluted to suit the taste of the maker, before the product is offered for sale.

Evidently, there is serious danger that in practicing these methods, the vinegar maker may turn out a product that does not come up to any fair standard.

Again, correspondents mention the frequent addition of sugar solutions to the cider in order to increase the strength of the vinegar and eke out the more costly supply of high flavored apple juice.

Descriptions of the samples received were given as follows:

Bedford County:

No. 15. Made by Isaac Bayer, Loysburg, Pa., from 1893 cider; the cider was made from mixed varieties of fair quality, but rather acid. The trees were situated on a sandy lowland with a northerly exposure. No water was added.

No. 16. Made by John Bechtel, New Enterprise, Pa., from 1894 cider; the apples were of Baldwin and Pound varieties, the cider was rather acid. The trees grew upon a clay upland of varying exposure. No water added.

Both samples were taken by Mr. J. S. Biddle, of Loysburg, Pa.

Berks County:

No. 11. Made by Charles Minnich, of North Heidelberg, Pa., from 1893 cider, of Baldwin, Rambo, Lady's Finger and other varieties. The apples were beginning to rot, and were grown upon a limestone, upland soil of northerly exposure.

No. 12. From the same orchard, cider of 1894.

Both samples were sent by the maker.

Bucks County:

No. 26. Made by R. P. Lovett, Fallsington, Pa., from 1893 cider; cider was made from good Smith's Cider and Russet apples, grown upon a level, brown loam upland.

No. 27. Made by H. W. Satterthwaite, Fallsington, Pa., from 1893 cider. The cider was made from good apples of mixed variety, chiefly "Smith's Cider," grown upon a good brown loam, upland soil, of southerly and easterly exposures. The quality of the cider was medium.

No. 28. Made by William Baldwin, Morrisville, Pa., from 1892 cider. The cider was made from very good "Smith's Cider" apples, grown upon a sandy loam, upland soil of a slightly northerly exposure; the quality of the cider was good.

These samples were sent by Mr. R. P. Lovett, Fallsington, Pa.

Butler County:

No. 59. Made by S. L. Beaver, Millerstown, Pa., from 1893 cider, to which newer cider has been added. The cider was made from several winter varieties, wind-falls being used. The soil was sandy, situated in a valley, with a slight northerly exposure.

No. 60. Made by G. E. Beaver, Millerstown, Pa., from 1892 cider, to which newer cider has since been added. Cider made from wind-falls of winter varieties. Slate, mixed with limestone clay soil.

Samples sent by Mr. G. E. Beaver.

Centre County:

Samples made and sent by Mr. W. P. Fisher, Fleming, Pa., without statement as to age.

No. 20974. From the "Sweet Vandever" apples.

No. 20975. From "Newtown Pippins."

No. 20976. From mixed varieties.

Clarion County:

No. 9. Made and sent by William Shanafelt, Brinkerton, Pa., 1893 cider, from good apples of mixed varieties; cider of good quality. Trees grown upon good upland soil of northerly exposure.

Clearfield County:

No. 31. Made by D. W. Reed, Lumber City, Pa., from 1893 cider, of a native variety; cider, "probably sour;" soil, a light clay and slate upland of southwesterly exposure.

No. 32. Made by Jno. Moore, Lumber City, Pa., from 1891 or 1892 cider, of mixed sour apples; cider, sour; soil, a slaty loam upland, of northeasterly exposure.

Both samples sent by Mr. J. P. Watts, of Kermoor, Pa.

Clinton County:

No. 49. Made by C. J. Sigmund, Salona, Pa., from 1893 cider, of mixed varieties; cider, excellent; soil, limestone upland.

No. 50. Made by T. S. Snodgrass, Parvin, Pa., from 1893 cider, of mixed varieties; cider, good; soil, upland limestone of southerly exposure.

Both samples sent by Mr. J. A. Herr, Cedar Springs, Pa.

Columbia County:

No. 41. Made by Sylvester Kitchen, Welliversville, Pa., from cider of uncertain age, made from sound, mixed apples; cider, sweet; soil, gravelly upland, with clay subsoil and southerly exposure, in a good fruit section.

No. 42. Made by A. P. Young, Millville, Pa., from cider of uncertain age, made from sound, mixed apples; cider, sweet; soil, upland clay slate, of southerly exposure, in Greenwood valley, not a first-class fruit region.

In both cases, a vinegar barrel is kept and is filled, spring and fall, from other barrels holding vinegar of less advanced strength. Samples sent by Mr. A. P. Young.

Cumberland County:

No. 57. Made by David Comerer, Shippensburg, Pa., from cider pressed in 1893, or earlier, from wind-falls of mixed sorts; soil, upland limestone of southerly exposure.

No. 58. Similar to 57, but from apples grown on a slate upland, of northeasterly exposure.

Samples sent by Mr. B. D. Biggs, Shippensburg, Pa.

Delaware County:

No. 13. Not described.

No. 14. Made by Hibberd Miller, Brandywine Summit, Pa., from November cider, year not given; apples sound and of Baldwin, Smokehouse and Smith's Cider varieties; soil, upland loam.

Both samples sent by Hon. George E. Heyburn, Chadd's Ford, Pa.

Franklin County:

No. 1. Made by Henry Omwake, Greencastle, Pa., from cider pressed in 1888; apples, wind-falls of mixed early sorts; soil, gravelly limestone, upland, of westerly exposure.

No. 2. Made by Josiah Lesher, Greencastle, Pa., from cider pressed in 1891, or earlier; otherwise, description as above.

Samples sent by Mr. Omwake.

Juniata County:

No. 7. Made by James Milliken, McCulloch's Mills, Pa., from October cider, 1893; from fair apples of mixed sorts; soil, limestone loam, lowland, of southerly exposure.

No. 8. Made from 1894 cider from various grafted sorts; soil, slate upland, of southerly exposure.

Sent by Mr. J. C. Crawford, McCulloch's Mills, Pa.

Lackawanna County:

No. 33. Made by J. L. Stone, Waverly, Pa., from 1894 cider; apples, usually somewhat decayed, from Baldwin, Greening and Spice varieties chiefly; soil, stony, clay loam upland.

No. 34. Made by Silas A. Whitney, Dalton, Pa., from 1893 cider· did not acetify well during first two years; otherwise, description as for No. 33.

Samples sent by Mr. Stone.

Lancaster County:

No. 55. Made by C. B. Snyder, Lititz, Pa., from cider of uncertain age; apples, windfalls of mixed sorts; cider contains washings from the press; soil, slate upland.

No. 56. Made by Jacob Bucher, Lititz, Pa.; description as in No. 55, except that press washings were not added, and soil was limestone upland.

In this locality, new vinegar is regularly mixed with old, in stock barrels; hence uncertainty as to age. Samples sent by Major J. R. Bricker, Lititz, Pa.

Lawrence County:

No. 39. Made by Mr. Isaac T. Gibson, New Wilmington, Pa., from November cider, 1892; apples, sound, large white sweet apples; soil, heavy clay upland, of southeasterly exposure; vinegar has been frozen, but was not tapped while in that state.

No. 40. Made by Jacob H. Detweiler, New Wilmington, Pa., from November cider, 1893; apples, sound, mixed; soil, gravelly clay upland of southerly exposure; vinegar racked and strained twice a year.

Samples sent by Mr. J. B. Johnston, New Wilmington.

Lehigh County:

No. 17. Made by H. E. E. Roeder, Hosensack, Pa., from 1894 cider of good quality; apples, fair, mixed; soil, red gravel of southerly exposure.

No. 18. Made by C. E. Roeder, Macungie, Pa., from 1893 cider of good quality; apples, fair, mixed; soil, gravel upland, of northerly exposure.

No. 19. Made by Jacob Barnes, Allentown, Pa., from good 1893 cider; apples, fair, mixed; soil, gravel upland, of northerly exposure; a little rain water is added as vinegar is withdrawn from the barrel.

Usual in this locality to add water or new cider to vinegar.

Samples sent by Mr. Jacob Barnes.

Mifflin County:

No. 20. Made by A. B. Cummins, Milroy, Pa., from very sweet October cider, 1893; apples, very good, "Winter Sweets;" soil, slaty upland, excellent for fruit.

No. 21. Made by R. A. Naginey, Milroy, Pa., from October cider 1893; apples, wind-falls of winter sorts; soil, clay upland of northeasterly exposure.

Samples sent by Mr. Naginey.

Monroe County:

No. 43. Made by Aaron Smith, Minsi, Pa., from 1892 cider; apples, wind-falls of sour varieties; cider, good; soil, limestone clay, upland of southeasterly exposure.

No. 44. Made by O. Zimmerman, Minsi, Pa., description like that for No. 43.

The addition of sugar or water is common. Fruit from these orchards is not so highly colored as is that from orchards at altitudes of 1,500 feet or upwards.

Samples sent by Mr. Randall Bisbing, Minsi, Pa.

Northumberland County:

No. 51. Made by W. A. Montgomery, Pottsgrove, Pa., from October cider, 1892; apples, unripe Rambo, Northern Spy and Pippins; soil, alluvial bottom; cider, good; orchard highly productive.

No. 52. Made by Minner G. Marsh, Pottsgrove, Pa., from October cider, 1890; apples, unripe Smokehouse, Northern Spy and Baldwin; soil, limestone gravel upland, of southerly exposure; orchard very productive.

Samples sent by Mr. C. M. Marsh, Pottsgrove, Pa.

Pike County:

No. 3. Made by E. Warner, Milford, Pa., from 1891 cider; cider, of good quality, from second grade Roxbury Russets; soil, level, sandy loam lowland.

No. 4. Made by J. H. Van Etten, Milford, Pa., from 1893 cider; apples, sound, native sorts; soil, gravelly loam upland, Hamilton shale, of southerly exposure.

Samples sent by Mr. Van Etten.

Schuylkill County:

No. 24. Made by W. H. Stout, Pine Grove, Pa., from 1893 cider; apples, of mixed variety unsuited for storage; soil, shale upland of southerly exposure.

No. 25. Made by Mr. Heisler, Pine Grove, Pa.; hand press used, which requires addition of a little water for cleaning.

Samples sent by Mr. Stout.

Somerset County:

No. 53. Made by Urich Trent, Somerset, Pa., from 1893 apples of sour varieties; cider, sour and of dark color; soil, slate upland of posure.

No. 54. Made by E. E. Pugh, Somerset, Pa., from 1893 apples of sour varieties; soil, limestone clay upland of southerly ex- northerly exposure.

Samples sent by Mr. Jacob S. Miller, Somerset, Pa.

Sullivan County:

No. 61. Made by Perry Benfield, Forksville, Pa., from 1893 apples, sound, of fall varieties; soil, gravelly upland of northerly exposure.

Sent by Mr. D. T. Huckell, Forksville, Pa.

Susquehanna County:

No. 35. Made by Charles Welch, Montrose, Pa., from 1892 apples, sound, of native sorts; cider, very fine; soil, wet, clay loam, of easterly exposure.

No. 36. Made by R. S. Searle, Montrose, Pa., from 1893 apples, ripe, of grafted fall varieties; soil, dry, red shale upland, of northerly exposure.

No. 37. Made by J. Townsend, Montrose, Pa., from 1892 apples; no additions.

Samples sent by Mr. Searle.

Tioga County:

No. 47. Made by N. Campbell, Wellsboro, Pa., from 1888 apples, of mixed, grafted sorts; cider, good; soil, clay upland of southerly exposure.

No. 48. Made by H. D. Wheeler, Wellsboro, Pa., from 1893 apples; description as is No. 47, except that exposure is westerly.

Customary to add sugar and water to vinegar.

Samples sent by Mr. F. E. Field, Balsam, Pa.

Union County:

No. 5. Made by John A. Gundy, Lewisburg, Pa., from cider pressed in 1893, or earlier; cider, good; apples, wind-falls from mixed varieties; soil, limestone gravel upland, of southeasterly exposure.

No. 6. Made by Sol. W. Brown, Lewisburg, Pa.; description as for No. 5.

Samples sent by Mr. Gundy.

Warren County:

No. 22. Made by B. F. Mead, Warren, Pa., from 1893 apples, of mixed sorts; soil, clay, upland of southerly exposure; good fruit land.

No. 23. Made by E. Phillips, Sugar Grove, Pa.; description as for No. 22.

Samples sent by Mr. R. J. Weld, Sugar Grove, Pa.

Washington County:

No. 62. Made by Mr. Murdock, West Middletown, Pa., from October apples, 1893; sound wind-falls of Rambo variety; cider, fine; soil, freestone, clay lowland, of southerly exposure.

No. 63. Made by J. S. Liggett, Independence, Pa., from 1891 apples, of mixed sorts; cider, fine; soil, freestone, clay upland, of westerly exposure.

Samples sent by Mr. Liggett.

Wayne County:

No. 45. Made by W. C. Perham, Niagara, Pa., from 1893 apples, of native sorts; cider, good; soil, clay upland, with easterly exposure. Vinegar not exposed to the air.

No. 46. Made by J. N. Hull, White's Valley, Pa., from cider two to five years old, from sour varieties; soil, clay upland of southerly exposure.

Samples sent by Mr. Perham.

Westmoreland County:

No. 29. Made by Samuel Barnhart, Greensburg, Pa., from 1893 apples, chiefly Baldwins, of medium quality; cider, good; soil, light, sand upland of northerly exposure.

No. 30. Made by W. R. Barnhart, Greensburg, Pa.; description as for No. 29, except as to soil, which is a very heavy limestone upland, with southerly exposure.

Samples sent by Mr. George S. Barnhart, Greensburg, Pa.

ANALYSES.

The samples were received, analyzed and the results tabulated by Walter J. Keith, Ph. D., assisted by Warren P. Smiley, B. S., both of the chemical department of the Pennsylvania State College, and the writer is much indebted to them for their skill and care in the conduct of the work.

Three determinations were made upon each sample, viz: the specific gravity at 15° Centigrade, the acidity and the non-volatile solids. The specific gravity was determined by use of a Westphal balance. In determining the acidity, a large portion of the vinegar was diluted with nine volumes of distilled water, the mixture thoroughly shaken, and the acidity of duplicate portions of the dilute fluid determined by means of a standard solution of caustic soda, phenol-phthalein—a coloring substance which is white and cloudy in the presence of acid, but a deep beautiful red in the presence of alkali—being used to indicate when enough alkali had been added to neutralize the acid.

The solids were determined by measuring out a known volume (5 cc) of the vinegar into small, weighed porcelain crucibles. The crucibles were then heated over an open steam bath until most of the liquid had evaporated, and then the drying was completed in a water-oven until successive weighings at intervals of an hour showed that volatilization had practically ceased. These determinations were also made in duplicate. The weight of vinegar taken was estimated from the volume used and the specific gravity of the liquid.

The results are shown in the following table, the acidity being expressed in terms of absolute acetic acid:

VINEGAR ANALYSES.

County.	Sample number.	Specific gravity at 15° Centigrade.	Acetic acid.	Solids.	Remarks.
			Per cent.	*Per cent.*	
Bedford.	15*	1.001	2.20	0.96	Over-aged; was sharper a year ago.
	16	1.022	4.47	4.22	
Berks,	11	1.012	4.23	2.39	
	12	1.008	2.26	3.12	From apples beginning to rot.
Bucks,	26	1.016	6.56	1.73	
	27	1.033	7.00	5.97	
	28	1.015	5.37	2.29	
Butler,	59	1.015	6.77	1.73	Mixed with cider of later years.
	60	1.011	4.62	1.70	Mixed with cider of later years.
Centre,	20,974	1.0219	8.28	2.68	
	20,975	1.0166	7.95	2.26	
	20,976	1.0178	3.54	2.92	
Clarion,	9	1.010	5.18	2.13	
Clearfield,	31*	0.997	0.86	1.52	Contained alcohol.
	32	1.014	5.95	1.18	
Clinton,	49	1.0195	5.75	3.17	
	50	1.014	2.61	3.88	
Columbia,	41	1.0185	5.20	3.66	Has diminished in acidity.
	42	1.0095	3.90	2.83	Has diminished in acidity.
Cumberland,	57	1.021	5.16	3.79	
	58	1.015	2.90	2.94	
Delaware,	13	1.013	4.37	1.93	
	14	1.013	3.98	2.36	
Franklin,	1	1.019	5.88	2.77	
	2	1.018	4.11	3.68	
Juniata,	7	1.011	3.82	1.62	
	8	1.003	1.93	1.62	
Lackawanna,	33	1.019	5.22	3.20	
	34	1.0135	5.23	1.67	Was very slow in turning to vinegar.
Lancaster,	55	1.013	3.54	2.43	Mixed with older vinegar; contains washings from the cider-press.
	56	1.013	4.44	2.14	
Lawrence,	39	1.029	8.79	4.45	
	40	1.010	4.11	1.95	Strained every 6 months while making.
Lehigh,	17	1.011	4.39	1.85	
	18	1.013	4.50	1.82	
	19*	1.0105	3.66	1.47	A little rain-water added.
Mifflin,	20	1.023	5.01	4.39	
	21	1.009	4.46	2.06	
Monroe,	43	1.010	3.12	2.70	
	44*	1.0015	0.90	1.21	
Northumberland,	51	1.011	4.65	1.73	
	52	1.021	6.11	3.17	
Pike,	3	1.018	6.55	2.28	
	4	1.007	3.32	2.23	
Schuylkill,	24	1.009	2.78	2.94	
	25	1.011	4.30	1.92	Made on hand-press, with probable addition of a little water.
Somerset,	53	1.008	3.54	2.04	
	54*	1.006	1.72	2.12	Cider very sour.
Sullivan,	61	1.012	5.09	1.46	
Susquehanna,	35	1.026	5.46	4.34	
	36	1.016	6.02	2.42	
	37	1.012	4.62	1.38	
Tioga,	47	1.015	4.65	2.42	
	48	1.018	6.56	2.26	
Union,	5	1.019	6.90	2.36	
	6	1.019	5.85	2.95	

VINEGAR ANALYSES—*Continued.*

County.	Sample number.	Specific gravity at 15° Centigrade.	Acetic acid.	Solids.	Remarks.
			Per cent.	*Per cent.*	
Warren	22	1.022	5.53	3.62	
	23	1.0155	6.16	2.40	
Washington	62*	0.999	0.76	3.40	Contains alcohol.
	63	1.013	5.93	2.12	
Wayne	45*	0.999	1.54	1.91	Contains alcohol. Not exposed to the air.
	46	1.0125	3.98	3.08	
Westmoreland	29	1.017	4.49	2.58	
	30	1.009	2.38	1.37	
Mean	.....	1.015	4.90	2.60	

*Omitted from the average.

Of the sixty-four samples thus analyzed, thirty-five, or over one-half, fall below the legal standard, viz: Four per cent. of acidity and two per cent. of non-volatile solids; nine are deficient in both acid and solids; fourteen are deficient in acidity only, and thirteen others in solids only. The great proportion of deficient vinegar in this lot of samples is surprising when it is remembered that they have been carefully selected to represent the most reliable vinegars of the several counties from which they were sent. In the Pennsylvania vinegars of domestic make, taken as a whole, the probability is great that a much larger proportion of deficient samples would be found. These figures demand a closer examination, in view of their important bearing upon the State standard.

SOLIDS.

Of the twenty-one samples having less than two per cent. of solids, five samples run from 1.75 to 1.99 per cent., and one of these, Schuylkill, No. 25, had a little water added, and another, Lawrence, No. 40, was frequently strained; nine from 1.50 to 1.74 per cent. and only seven fall below 1.50 per cent.; of these seven, two have so nearly this amount of solids that analytical error will suffice to explain the deficiency below that amount, and in one of these cases, Lehigh, No. 19, a little water had been added to the vinegar, as shown by the maker's statement; three of the other vinegars were made from sour apples; of the remaining three, nothing is said concerning the character of the cider. Of the Bedford sample, No. 15, it is stated that it was "over-aged," and that no additions have been made; it is questionable, however, whether this over-aging accounts for the deficient solids; the same statement is made of the Columbia samples, Nos. 41 and 42, but both of these have solids much above the standard amount.

The above results clearly indicate that two per cent. of solids is not the least amount that an honestly made vinegar from good cider may contain; 1.50 per cent., is in the opinion of the writer, the highest figure that should be adopted as a minimum requirement for cider vinegar solids. On the other hand, properly made vinegars from good cider are quite certain to attain this percentage.

In this statement, the writer simply reaffirms the opinions of a number of other investigators: A. H. Allen[1] fixes the range of solids (for English cider vinegars) at 1.5 to 1.8 per cent. Charles H. Steinkamp,[4] from the examination of European vinegars, fixes the range at 1.5 to 2 per cent.; while Dr. B. F. Davenport,[3] long vinegar inspector of the city of Boston, cites upward of twenty authorities who fix the minimum for cider solids vinegar at 1.5 per cent.; although Deherain,[1] from French analyses, says that less than two per-cent. indicates dilution.

Not only do certain samples show a very low content of solids, but others run very high; five samples contain over four per cent., one of them, 5.79 per cent.; eleven others contain between three and four per cent.

Acidity.

Of the twenty-one samples deficient in acidity, it is evident from the low specific gravities in most cases, that this is due to the presence in them of alcohol; which, owing to unfavorable conditions of vinegar making, failed to be converted into acetic acid.

Such cases are the following:

Bedford, No. 15; Berks, No. 12; Clearfield, No. 31; Columbia, No. 42; Juniata, No. 7; Juniata, No. 8; Monroe, No. 43; Monroe, No. 44; Pike, No. 4; Schuylkill, No. 24; Somerset, No. 53; Somerset, No. 54; Washington, No. 62; Wayne, No. 45; Wayne, No. 46; Westmoreland, No. 30.

That is, there are left only five cases in which the low acidity is not very clearly due to incomplete conversion of the alcohol to acetic acid.

In further proof of the fact that the low acidity is due to this cause, two samples, Washington, No. 62, and Wayne, No. 45, both having the specific gravity, 0.999, and having the respective acidities, 0.76 and 1.54 per cent., were neutralized by alkali, so that their acetic acid was tied up in a non-volatile compound; thereupon, they were distilled, and enough alcohol was found in the distillates to correspond to 7.7 per cent. of No. 62, and 6 per cent. of No. 45.

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[1] Commercial Organic Analysis, I, 389.

[2] Bulletin Soc. Chim., **15**, 456.

[3] Doc. 62, 1883, City of Boston.

[4] Analyse de Matieres Agricoles, 2d edition, p. 685.

Undoubtedly, the deficiency of acid in the sixteen samples above listed could, in most instances, have been avoided by proper care. During their storage for a few weeks in the warmer air of the laboratory, there has been a marked tendency to increase in the density of these vinegars; as they were preserved in well-stoppered bottles, the change is evidently due to the conversion of the alcohol into acetic acid. In the sample, Warren, No. 23, the acidity was, at first, 6.16 per cent.; but now, almost six weeks later, it is 7.03 per cent.; a gain of nearly one-seventh of the amount originally present.

It is clear that by a little more careful management of the domestic vinegar manufacture, the too general tendency to make an article low in acid, can be readily overcome.

A number of cases occur in which, by reason of low specific gravity, it appears, that, although the acidity is up to standard, acetification is still incomplete; among them may be mentioned:

Butler, No. 60; Clarion, No. 19; Lehigh, No. 17; Lawrence, No. 40; Mifflin, No. 21; Northumberland, No. 51; Schuylkill, No. 25.

In many cases, very high acidity was observed; Lawrence, No. 39, heading the list with 8.79 per cent., while eleven others had 6 per cent. or over, and fifteen others from 5 to 6 per cent. In other words, very nearly one-half of the samples had an acidity of 5 per cent. and upwards.

It remains to consider the five cases in which the acidity was below four per cent., but the specific gravity was not so low as to clearly indicate the presence of much unacetified alcohol. Delaware, No. 14, is so nearly standard that it may fairly be so considered; Lancaster, No. 55, was mixed with newly forming vinegar, and contained the washings from the cider press, as well; it may, therefore, be dropped from consideration as abnormal. Three samples remain, Centre, No. 20,976; Clinton, No. 50, and Cumberland, No. 58; although the specific gravities of these samples are up to normal, it is highly probable that they have not been completely acetified. For Warren, No. 23, which gained so rapidly in acidity during its standing in the warm air of the laboratory, had, when it was first received, a specific gravity fully up to the average, viz: 1.0155.

Of the other investigators whose results as to solids have been given in an earlier paragraph, Allen and Steinkamp say that cider vinegar contains 3.5 to 6 per cent. of acetic acid.

Bearing of These Results Upon the Existing Standard.

These results, therefore, clearly show that the Pennsylvania vinegar law, although the standard it fixes is very similar to that fixed in a number of other states, would, if its requirements for solids were strictly enforced, subject at least one-third of the domestic vinegar makers to fine or imprisonment. These solids, too, add little to the condimental value of the vinegar and nothing to its preservative qualities; nor will any care in the manufacture prevent a deficiency in an otherwise good, normal vinegar.

These analyses also indicate that one-third of the domestic vinegars are below standard in acidity. Close examination reveals the fact, however, that, almost without exception, this deficiency is due to unfavorable conditions of manufacture which, with reasonable care and intelligent management of his business, the domestic manufacturer can prevent. The principal value of the vinegar is due to the acetic acid it contains; a deficiency in this ingredient seriously impairs this value. The consumer has a right to expect a good product, made carefully and intelligently. It is believed, therefore, that the existing standard for acidity can work no undeserved hardship, providing that the domestic manufacturer have at command a cheap and simple test for the degree of acidity of his product.

VINEGAR TESTS.

The principal simple test now offered to the domestic maker and to the official sampler of vinegars, depends for its value upon a variation from the normal density or specific gravity of the vinegar with its departure from standard strength. Vinegar is chiefly composed of water, and differs from water in weight, density or specific gravity only by reason of the other substances present, viz: acetic acid and solids, both of which tend, though in unequal degree, to make the vinegar heavier; and alcohol, which tends to make it lighter than water.

The instrument used is an elongated glass bulb, weighted at one end so that it may stand erect in the liquid, and drawn out into a narrow spindle at the other end; the spindle is marked with a line to which the bulb is expected to sink in standard vinegar, if it does not sink so far, the vinegar is heavier than standard vinegar and is assumed to be above standard in acid and solids; if it sinks so that the line is submerged, the vinegar is lighter than standard and is supposed to be deficient in acid and solids.

Similar instruments are highly useful in determining the strength of solutions in which there is only a *single* varying constituent. Unfortunately, cider vinegar is not such a liquid, and this sort of a test it utterly misleading in its indications when applied to this vinegar.

The normal specific gravity of standard cider vinegar is commonly stated to be 1,013 to 1.016; but in the carefully selected samples above mentioned, it ranged from 0.997 to 1.029. If we accept a specific gravity of 1.013 as normal. examination of the analytical results shows that three samples having four per cent. of acids and two per cent. of solids, fell below this specific gravity; on the other hand, there are five samples having a density of not less than 1.013, that are deficient in acidity; there are five other samples having the standard acidity, but having solids ranging from 1.5 to 2 per cent., and one sample having less than 1.5 per cent. of solids, but all having a density of at least 1.013. Six of the samples have exactly this density, but their acidity ranges from 3.54 to 5.93 per cent., and their solids from 1.83 to 2.43 per cent.

These figures clearly confirm the previous statement of the utter uselessness of this test to determine whether cider vinegar is standard. If, however, a domestic vinegar maker finds the acidity of his vinegar somewhat deficient, and knows that the cider received no addition of water, he may judge quite well from the use of an instrument showing the absolute density of the vinegar as compared with water, whether or not any unacetified alcohol remains; this would almost certainly be true if the density were less than 1.011.

A Test for Acidity

No simple test, adapted for the use of the farmer, has been devised to determine vinegar solids.

The writer has, however, devised a very simple method for use of the domestic makers in determining the acidity of their vinegars. The method is simply a modification of that devised by Prof. Farrington for testing the acidity of ripening cream.

By means of a pipette, twenty cubic centimeters (a little less than an ounce) of the clear vinegar is measured out and discharged into a clean tumbler or china cup. A pipette is a long glass tube, drawn to a point at the lower end and blown into a long bulb near the middle. The lower end of the tube is dipped well down into the vinegar, the mouth applied to the upper end of the tube, and the vinegar drawn up through the bulb, and somewhat higher than the mark on the upper portion of the tube; the tube being held about the bulb by the left hand, and, near the upper end of the tube, by the thumb and last three fingers of the right hand, as soon as the vinegar has been drawn up far enough, the right forefinger is quickly slipped over the upper opening of the tube and firmly pressed down. The pipette is then lifted from the vinegar, and by carefully reducing the pressure of the forefinger, the liquid is allowed to run out of the pipette, drop by drop, until the liquid in the centre is just on a level with the mark. The pressure is again increased, the pipette held over the tumbler and the vinegar carefully discharged into it without loss of a drop; allow the pipette to drain for a few seconds and then set it aside. Rinsings need not be added, because the pipette is made so as to discharge twenty cubic centimetres, and not simply to hold that amount. Now add to the vinegar, two or three times its volume of pure, soft water, so as to diminish the intensity of its brown color.

Taking 1.014 as the average specific gravity of good cider vinegar, the weight of the twenty cubic centimetres would be 20.28 grammes. One hundredth part of this, or one per cent., would be .2028 grammes.

Now, if caustic soda be added to acetic acid, it forms sodium acetate, a neutral salt also soluble in water. Any excess of the caustic soda, however slight, makes the liquid alkaline. There is a coloring substance, phenol-phthalein, which, in an acid liquid, is slightly yellowish and cloudy, but in a liquid alkaline in the slightest degree, turns pinkish first, and then, as the alkalinity increases a little more, a deep, bright red.

To neutralize .2028 grammes of acetic acid requires .1048 grammes of sodium oxide, or .1352 grammes of sodium hydrate. Tables each containing this amount of soda, together with a trace of phenol-phthalein, will be prepared to accompany the pipette in the testing outfit.

If four of these tablets be dropped into the diluted vinegar and carefully stirred until they are thoroughly dissolved, they will be exactly neutralized by four per cent. of acid in the vinegar, and the red color will entirely disappear; if the red color remains, the vinegar does not contain as much as four per cent. of acid and is, therefore, below standard.

It will not be at all difficult to determine approximately the degree of deficiency or excess in acidity. Five tablets will correspond to five per cent. of acidity, three to three per cent., and so forth. To measure halves of a per cent., procure a tall, narrow bottle with such a lip as will make it possible to easily control the outflow of liquid. Measure out by aid of the pipette, twenty centimeters of water into the bottle; by means of a file or by use of a strip of gummed paper, mark on the side of the bottle the level of the top of the water; then add a second portion of twenty centimeters and again mark the level of the liquid. Now, dissolve one tablet in this water, shaking carefully so that there may be no loss. Pour the liquid out carefully into the vinegar tumbler until it is brought down so far in the bottle that it is on the level of the first mark when the bottle is in an upright position; by this simple means, a solution containing one-half the tablet, corresponding to one-half per cent. of acetic acid, may be measured out quite accurately.

By use of such a simple test for acidity, the domestic vinegar maker can keep a close control upon the progress of acetification in his vinegar, can avoid the premature sale of an article still below standard in acid, can ensure the merchant to whom he sells against the annoyance and injury which would come from the detected sale of a vinegar under standard; and can secure the knowledge of facts that would warrant him in guaranteeing an article to have a definite percentage of acidity above standard.

The same test will be useful to honest merchants in protecting themselves against the unwitting purchase from careless or unscrupulous makers of vinegar, of any kind, deficient in acidity.

With so simple and inexpensive a test at command, there is no reason why the existing standard of acidity should not be retained and enforced.